A comparative effectiveness study of patient-rated and radiographic outcome after 2 types of decompression with fusion for spondylotic myelopathy: anterior cervical discectomy versus corpectomy

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Abstract: OBJECT: Both anterior cervical discectomy with fusion (ACDF) and anterior cervical corpectomy with fusion (ACCF) are used to treat cervical spondylotic myelopathy; however, there is currently no evidence for the superiority of one over the other in terms of patient-rated outcomes. This comparative effectiveness study compared the patient-rated and radiographic outcomes of 2-level ACDF versus 1-level ACCF. METHODS: This single-center study was nested within the EuroSpine Spine Tango data acquisition system. Inclusion criteria were the following: consecutive patients presenting with signs of cervical spondylotic myelopathy who underwent 2-level ACDF or 1-level ACCF between 2004 and 2011. Before and 12 months after surgery, patients completed the multidimensional Core Outcome Measures Index (COMI) and also rated global treatment outcome and satisfaction with care on 5-point Likert scales. Cervical lordosis, segmental height, and fusion rate were assessed radiographically before and immediately after surgery and at the last follow-up (20.4 ± 13.7 months, mean ± SD). RESULTS: In total, 118 consecutive patients (80 in the ACDF group and 38 in the ACCF group) were included. Age, sex, comorbidity, baseline symptoms, baseline radiographic data, operation duration, and complication rates did not differ significantly between the 2 groups. Blood loss was significantly ($p < 0.04$) lower in the ACDF group. Postoperative mean segmental height was significantly ($p = 0.0006$) greater for ACDF (42.0 ± 4.2 mm, mean ± SD) than for ACCF (39.0 ± 4.0 mm), and global average lordosis improved to a significantly ($p = 0.003$) greater extent in ACDF (by 1.6° ± 4.1°) than in ACCF (by -1.0° ± 4.0°). Fusion rates for ACDF were 97.5% and for ACCF were 94.7% ($p = 0.59$). The 12-month patient-rated outcomes did not differ significantly between ACDF and ACCF: 82.4% and 68.6% had a good global outcome (operation helped/helped a lot) ($p = 0.10$), 86.5% and 82.9% were satisfied/very satisfied with care ($p = 0.62$), and the reduction in the multidimensional COMI was 2.8 ± 2.7 and 2.2 ± 3 points ($p = 0.30$), respectively. The postoperative increase in lordosis angle showed low but significant correlations with the improvement in arm pain ($r = 0.25$, $p = 0.014$), highest pain ($r = 0.25$, $p = 0.013$), and function ($r = 0.24$, $p = 0.016$). CONCLUSIONS: Both ACDF and ACCF are safe and effective in the treatment of cervical spondylotic myelopathy, indicated by similarly good patient-rated outcomes 1 year after surgery. This precludes any conclusions regarding the superiority of one technique over the other, although it should be noted that ACDF resulted in less blood loss and greater improvements in cervical lordosis and segmental height than ACCF. Patients with improved lordosis angle had a better clinical outcome.

DOI: https://doi.org/10.3171/2013.3.FOCUS1396

Neurosurg Focus 35 (1):E4, 2013

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Object. Both anterior cervical discectomy with fusion (ACDF) and anterior cervical corpectomy with fusion (ACCF) are used to treat cervical spondylotic myelopathy; however, there is currently no evidence for the superiority of one over the other in terms of patient-rated outcomes. This comparative effectiveness study compared the patient-rated and radiographic outcomes of 2-level ACDF versus 1-level ACCF.

Methods. This single-center study was nested within the EuroSpine Spine Tango data acquisition system. Inclusion criteria were the following: consecutive patients presenting with signs of cervical spondylotic myelopathy who underwent 2-level ACDF or 1-level ACCF between 2004 and 2011. Before and 12 months after surgery, patients completed the multidimensional Core Outcome Measures Index (COMI) and also rated global treatment outcome and satisfaction with care on 5-point Likert scales. Cervical lordosis, segmental height, and fusion rate were assessed radiographically before and immediately after surgery and at the last follow-up (20.4 ± 13.7 months, mean ± SD).

Results. In total, 118 consecutive patients (80 in the ACDF group and 38 in the ACCF group) were included. Age, sex, comorbidity, baseline symptoms, baseline radiographic data, operation duration, and complication rates did not differ significantly between the 2 groups. Blood loss was significantly ($p < 0.04$) lower in the ACDF group. Postoperative mean segmental height was significantly ($p = 0.0006$) greater for ACDF (42.0 ± 4.2 mm, mean ± SD) than for ACCF (39.0 ± 4.0 mm), and global average lordosis improved to a significantly ($p = 0.003$) greater extent in ACDF (by 1.6° ± 4.1°) than in ACCF (by −1.0° ± 4.0°). Fusion rates for ACDF were 97.5% and for ACCF were 94.7% ($p = 0.59$). The 12-month patient-rated outcomes did not differ significantly between ACDF and ACCF: 82.4% and 68.6% had a good global outcome (operation helped/helped a lot) ($p = 0.10$), 86.5% and 82.9% were satisfied/very satisfied with care ($p = 0.62$), and the reduction in the multidimensional COMI was 2.8 ± 2.7 and 2.2 ± 3 points ($p = 0.30$), respectively. The postoperative increase in lordosis angle showed low but significant correlations with the improvement in arm pain ($r = 0.25$, $p = 0.014$), highest pain ($r = 0.25$, $p = 0.013$), and function ($r = 0.24$, $p = 0.016$).

Conclusions. Both ACDF and ACCF are safe and effective in the treatment of cervical spondylotic myelopathy, indicated by similarly good patient-rated outcomes 1 year after surgery. This precludes any conclusions regarding the superiority of one technique over the other, although it should be noted that ACDF resulted in less blood loss and greater improvements in cervical lordosis and segmental height than ACCF. Patients with improved lordosis angle had a better clinical outcome.

(http://thejns.org/doi/abs/10.3171/2013.3.FOCUS1396)

Key Words • **spondylotic myelopathy** • **anterior cervical discectomy fusion** • **anterior cervical corpectomy fusion** • **patient-rated outcome**

There is ongoing discussion in the literature regarding the optimal surgical approach to treat cervical spondylotic myelopathy.[16] Posterior approaches as well as anterior techniques such as ACDF and ACCF are the most commonly used approaches.[9,10,12,14] In both ACDF and ACCF, the spinal canal is decompressed anteriorly, and the segment(s) are then fused, with the goal of improving or stabilizing the myelopathy and alleviating the associated neck pain or radiculopathy. Although both techniques are widely used, there is currently no evidence for the superiority of one over the other in terms of patient-rated outcomes.[16] Most studies have compared differences in surgical technique, related complications, or physician-rated outcome. These studies have shown that ACCF is associated with good fusion rates, but with higher complication rates, a longer duration of surgery, and greater blood loss compared with ACDF.[12,14,15] Leaks of CSF and injury to the vertebral artery are also reported more frequently for ACCF.[10,14] Moreover, ACDF has been reported to better preserve the stability of the spinal

Abbreviations used in this paper: ACCF = anterior cervical corpectomy with fusion; ACDF = anterior cervical discectomy with fusion; COMI = Core Outcome Measures Index.

column after fusion.[16] However, the more limited surgical exposure compared with ACCF places this technique at higher risk of incomplete decompression, and the increased number of fusion surfaces in multilevel ACDF can lead to a higher risk of pseudarthrosis.[14,16]

Patient-rated outcome has rarely been examined in the aforementioned studies. In this comparative effectiveness study, we analyzed the patient-rated outcomes and radiographic outcomes of patients who had undergone ACDF or ACCF for the treatment of cervical spondylotic myelopathy.

Methods

Patient Data and Inclusion Criteria

This was a single-center study nested within the EuroSpine Spine Tango data acquisition system. It comprised a retrospective analysis of prospectively collected data. Cases were identified using the Spine Tango system and our local outcomes database and were verified by cross-checking with information in our local clinical information system. Inclusion criteria were the following: consecutive patients between 2004–2011 presenting with signs of myelopathy undergoing anterior cervical decompression with fusion at more than 1 level due to degenerative stenosis, treated with either 2-level ACDF or 1-level ACCF, who were German or English speakers and (after 2007) also Spanish, Italian, French, or Portuguese speakers. Exclusion criteria were the following: ACDF performed at nonconsecutive levels (floating fusion), both ACDF and ACCF performed during the same surgery, prior cervical fusion surgery, myelopathy associated with nondegenerative causes, and additional posterior instrumented fusion at the same levels.

Surgical Technique

The ACDF and ACCF techniques were performed as previously described via a standard cervical anterior approach.[2,12] After discectomy or corpectomy, either an iliac bone graft or a cage with or without plates was used for fusion. Harms titanium cages (DePuy) were used for ACCF and PEEK (polyetheretherketone) cages (Medtronic) for ACDF.

Data Acquisition System and Patient-Oriented Questionnaires

Using the prospective EuroSpine Spine Tango data acquisition system,[13] all relevant patient data were documented by the physician during the hospital stay, including pathology, previous treatment, patient comorbidity status assessed with the American Society of Anesthesiologists physical status score, surgical procedure, number of affected levels, duration of surgery (in categories, from < 1 to > 10 hours), blood loss (in categories from none to > 2000 ml), and both general and surgical complications.

Patients completed the multidimensional COMI questionnaire before and 12 months after surgery.[6] The questionnaire was sent to the patients by post, to be completed at home. The COMI (scored 0–10) consists of questions covering the domains of pain, function, symptom-specific well-being, general quality of life, and social and work disability.[6,7] In addition, the global treatment outcome at the 12-month follow-up was assessed with a question inquiring as to how much the operation had helped the neck problem overall (5 response categories: 1 = helped a lot, 2 = helped, 3 = helped a little bit, 4 = did not help, and 5 = made things worse). Patient-rated satisfaction with care was also rated using a 5-point Likert scale. (Patients were asked: ''Over the course of treatment for your neck problem how satisfied were you with the medical care in our hospital?'' Response categories were the following: 1 = very satisfied; 2 = satisfied; 3 = not satisfied, but also not dissatisfied; 4 = dissatisfied; and 5 = very dissatisfied.)

Radiographic Measurements

Radiographic measurements included segmental height, cervical lordosis, and fusion rate as described by Song et al.[14] Segmental height and lordosis were measured on plain lateral radiographs with the patient in the neutral position. Measurements were made before and within the first week after surgery and at the last follow-up. To assess segmental height, the distance between the midpoint of the involved cranial and caudal vertebral bodies was measured. Cervical lordosis was defined as the angle between the lower endplate of C-2 and the upper endplate of C-7 using the Cobb method. Fusion rate was defined either by the absence of motion between spinous processes on functional lateral plain radiographs (flexion/extension) or by bridging of the bone anterior or posterior to the cage or at the graft-endplate junction in cases where iliac bone had been implanted.[14]

Statistical Analysis

The significance of differences between the ACDF and ACCF groups for continuous, normally distributed data were analyzed using unpaired Student t-tests or repeated-measures ANOVA (for pre/post measures). Contingency analyses with chi-square or Fisher exact test were used to analyze the association between surgical group and categorical variables, and correlation of radiographic data to clinical outcome was determined using Pearson correlation coefficient (r value). For analysis, the global outcome was dichotomized into ''good'' (that is, operation helped or helped a lot) and ''poor'' (that is, operation only helped a little, did not help, or made things worse). Descriptive data are presented as the mean ± SD, and statistical significance was accepted at the $p < 0.05$ level.

Results

Study Groups

Of the 156 patients (91 males and 65 females) identified from the database who had undergone ACDF (n = 93) and ACCF (n = 63) for multilevel cervical spondylotic myelopathy, 118 were treated with either a consecutive 2-level ACDF (n = 80) or a 1-level ACCF (n = 38). These patients composed the groups under study. The distribution of the cervical segments operated on is shown in Table 1. In 25 (31%) of the 80 ACDF patients and 36 (95%) of the 38 ACCF patients, a cage (Harms titanium mesh or PEEK [polyetheretherketone]) was used for fusion, and in 55

TABLE 1: Overview of surgically treated segments

Factor	No. (%)	
	ACCF	ACDF
no. of corpectomies/discectomies	63	93
1	38 (60.3)	0 (0)
2	15 (23.8)	82 (88.2)
3	9 (14.3)	10 (10.8)
4	1 (1.6)	1 (1.1)
no. of included cervical segments	38	80
C3–5	6	11
C4–6	14	31
C5–7	17	38
C6–T1	1	0
fusion materials	38	80
cage	36	25
iliac bone	2	55
plate	38	60*
no plate	0	20†

* In the 60 cases of plate placement, 15 involved cages and 45 involved iliac bone.

† In the 20 cases without plates, 12 involved cages and 8 involved iliac bone.

(69%) of the 80 ACDF patients and 2 of the 36 ACCF patients (5%), iliac bone was used. Anterior plate fixation was used in 60 ACDF patients (75%) and in all ACCF patients.

No statistically significant difference ($p > 0.05$) was detected between the 2 groups in terms of age, sex, comorbidity, or baseline patient-rated measures (Table 2).

Surgery Details

The duration of surgeries did not differ significantly between the 2 groups ($p = 0.14$), with most of the surgeries lasting between 2 and 3 hours (Table 3). Data for rates of complications were available for 85% (68/80) of the ACDF patients and 82% (31/38) of the ACCF patients. Blood loss during surgery was significantly lower ($p = 0.04$) in the ACDF group than in the ACCF group, and both general as well as surgical perioperative complication rates were slightly, but not significantly, higher in the ACDF group (Table 3).

Radiographic Outcome

A summary of the radiographic outcomes is shown in Table 4. The 2 groups showed a similar segmental height and lordosis angle at baseline (statistical significance of the group difference in each case was $p > 0.05$). The last radiological follow-up was carried out at 20.1 ± 13.0 months (range 9.9–90.5 months) postoperatively for the ACDF group and 20.9 ± 15.1 months (range 11.6–80.5 months) for the ACCF group ($p > 0.05$). A statistically significant difference was detected between the groups for segmental height immediately postoperatively ($p = 0.0006$) and at the last follow-up ($p = 0.003$), with the ACDF group showing significantly greater improvements upon baseline values than the ACCF group (Table 4). In both groups, the 3- to 4-mm increase in segmental height seen postoperatively showed a significant ($p < 0.05$) approximately 2-mm decrease by the time of the last follow-up.

In the ACDF group, the cervical lordosis angle showed a slight increase compared with baseline values both immediately after surgery and at the last follow-up; in contrast, the ACCF group showed a slight reduction in cervical lordosis at comparable time points. This resulted in a significant ($p < 0.05$) difference between the groups for the change in lordosis angle over time (preoperative to postoperative, as well as preoperative to last follow-up). There was no significant change between the lordosis angle immediately after surgery and at the last follow-up in either the ACDF or the ACCF group ($p = 0.27$ and $p = 0.41$) (Table 4).

Fusion rates were 97% (78/80) in the ACDF group and 95% (36/38) in the ACCF group ($p = 0.59$). Three patients (4%) from the ACDF group and 2 patients (5%) from the ACCF group needed repeated surgery for adjacent-level disease by the time of the last follow-up.

Patient-Rated Outcomes

The 12-month questionnaire follow-up rate was 92.4%, with no significant difference ($p = 0.94$) between the ACDF (92.5%) and ACCF (92.1%) groups. All the patient-rated outcomes were slightly but not significantly better in the ACDF group than in the ACCF group. A good global outcome (operation helped/helped a lot) at the 12-month follow-up was reported by 82% of the ACDF patients and 69% of the ACCF patients ($p = 0.10$) (Table 5). In the ACDF group, 86% of patients were satisfied/very satisfied with their care compared with 83% in the ACCF group ($p = 0.62$). In each group, a statistically significant ($p < 0.0001$) and clinically relevant (≥ 2.2-point) reduction was detected in the multidimensional COMI score 12 months after surgery, with no significant difference in this score between the groups (Table 5).

Correlation of Radiographic Data to Clinical Outcome

Low but statistically significant correlations were detected between the change in pre- to postoperative lordosis angle and the changes (preoperative to 12-month follow-up) in arm pain ($r = 0.25$, $p = 0.04$), highest pain ($r = 0.25$, $p = 0.013$), and function ($r = 0.24$, $p = 0.016$), as measured with the COMI. None of the correlations between these same clinical measures and the change in segmental height (preoperative to postoperative) reached statistical significance. However, a significant difference was detected between those with a "good global outcome" and those with a "poor outcome" for both the increase in postoperative segmental height (4.4 ± 2.5 mm vs 2.0 ± 1.9 mm, respectively; $p < 0.0001$) and the change in lordosis angle (1.3° ± 3.8° vs −1.58° ± 5.1°, respectively; $p < 0.004$). The proportion of patients reporting a good global outcome did not differ significantly between the patients with solid fusion and those with pseudarthrosis (78 vs 67%, respectively, $p = 0.53$).

Discussion

In this study, we compared 2 different surgical tech-

TABLE 2: Baseline characteristics of the 2 treatment groups

Variable	ACCF (n = 38)*	ACDF (n = 80)*	p Value
age (yrs, mean [SD])	60.3 (11.1)	60.7 (9.9)	0.84
sex (no. of males)	25 (66%)	41 (51%)	0.14
comorbidity status (%)†			0.64
ASA 1	19.4	17.9	
ASA 2	67.7	61.2	
ASA 3	12.9	20.9	
baseline neck pain on 0–10 scale (mean [SD])‡	3.8 (3.1)	4.3 (2.9)	0.37
baseline arm pain on 0–10 scale (mean [SD])‡	4.7 (3.2)	4.7 (3.1)	0.95
baseline worst pain (either neck or arm) on 0–10 scale (mean [SD])‡	5.3 (3.1)	5.5 (2.7)	0.73
baseline function on 1–5 scale (mean [SD])§	3.2 (1.4)	3.3 (1.2)	0.71
baseline symptom-specific well-being on 1–5 scale (mean [SD])§	4.3 (1.2)	4.3 (1.1)	0.99
baseline general quality of life on 1–5 scale (mean [SD])§	3.4 (1.0)	3.6 (0.9)	0.52
baseline disability (social and work) on 1–5 scale (mean [SD])§	3.1 (1.7)	2.9 (1.6)	0.59
COMI sum score on 0–10 scale (mean [SD])	6.1 (2.9)	6.1 (2.3)	0.91

* Numbers were 36 undergoing ACCF and 76 undergoing ACDF for baseline patient-rated outcome data.
† Assessed as American Society of Anesthesiologists (ASA) physical status score.
‡ The 0–10 scales are based on a visual analog scale (VAS) ranging from 0 (no pain) to 10 (worst pain the patient can imagine).
§ The 1–5 scales are based on patient-rated evaluation of satisfaction: 1 = very satisfied; 2 = satisfied; 3 = not satisfied, but also not dissatisfied; 4 = dissatisfied; 5 = very dissatisfied.

niques, ACDF and ACCF, for the treatment of spondylotic myelopathy with regard to patient-rated and radiographic outcome. In the literature, there is still ongoing discussion about the superiority of one technique over the other, and previous studies have mostly compared groups with different numbers of operated levels and without any patient-rated outcomes.[4,5,8,14] Only a few studies have focused on specific comparisons including only patients with 2-level ACDF or 1-level ACCF.[10,11,15] The rationale for the selection of these subgroups resides in the fact that both techniques remove 2 intervertebral discs for the same extent of spinal canal stenosis.[15]

TABLE 3: Group differences in surgical details

Variable	ACCF (n = 31)*	ACDF (n = 68)*	p Value
operation duration			0.14
1–2 hrs	6.5%	8.8%	
2–3 hrs	64.5%	67.7%	
3–4 hrs	19.3%	23.5%	
>4 hrs	9.7%	0.0%	
blood loss			0.04†
none	0.0%	14.7%	
<500 ml	90.3%	82.4%	
500–1000 ml	9.7%	2.9%	
general complications (intraop/periop)	2/31 (6.5%)‡	7/68 (10.3%)‡	0.72
surgical complications (intraop/periop)	1/31 (3.2%)§	7/68 (10.3%)§	0.42

* Spine Tango form was not completed for all patients.
† For complications, the Fisher exact test was used to determine p values; p values < 0.05 were considered significant.
‡ ACCF complications: pulmonary (n = 2); ACDF: anesthesiological (n = 1), cardiovascular (n = 2), pulmonary (n = 2), cardiovascular and pulmonary (n = 1), kidney/urinary (n = 1), other (n = 1).
§ ACCF complications: bleeding outside spinal canal (n = 1); ACDF: nerve root damage (n = 1), nerve root damage and bleeding in spinal canal (n = 1), dural tear (n = 3), implant failure (n = 1), other (n = 1).

We present 1 of the largest series in the literature[10,11,15] comparing 2-level ACDF and 1-level ACCF. The results suggest that both techniques are safe and effective in the treatment of cervical spondylotic myelopathy and that they result in similarly good patient-oriented outcomes. The 2 groups had similar demographic/clinical characteristics and COMI scores at baseline, and showed a similar significant improvement in the COMI score 12 months after surgery (2.8 ± 2.7 points for ACDF and 2.2 ± 3 points for ACCF). In a study including 14 two-level ACDF and 17 one-level ACCF patients, Oh et al. reported a significant improvement in neck and arm pain visual analog scale scores in each group without significant differences in these scores between the groups.[10] We also showed an improvement in neck pain and arm pain in each group, together with significant improvements in function, symptom-specific well-being, quality of life, and disability (Table 5). In a meta-analysis, Jiang et al. reported that 6 out of 9 studies (including some studies with multilevel ACDF and ACCF) using a variety of outcome measurements found similar outcomes for the 2 treatments;[5] 3 other studies described a slightly but not significantly better clinical outcome for ACCF than for ACDF. For instance, Nirala et al. reported that a "good" or "excellent" clinical outcome was found in 87.0% of ACCF and 81.1% of ACDF patients.[8] There was a higher pseudarthrosis rate in the ACDF group in their study, and patients with pseudarthrosis had significantly poorer clin-

TABLE 4: Segmental height and cervical lordosis of ACDF and ACCF groups*

Variable	Preop	Postop	Last FU†	Difference Btwn Postop & Preop	Difference Btwn Last FU & Preop	p Value‡
segmental height (mm)						
ACDF (n = 73)	37.6 ± 4.6 (29.6–47.1)	42.0 ± 4.2 (34.1–50.1)	39.9 ± 4.3 (32.1–49.4)	4.4 ± 2.4 (0.5–11.6)	2.3 ± 2.5 (−4.4 to 8.6)	<0.0001
ACCF (n = 36)	36.2 ± 3.9 (28.7–42.2)	39.0 ± 4.0 (28.4–45.3)	37.3 ± 4.3 (24.9–45.3)	2.8 ± 2.5 (−2.1 to 5.6)	1.1 ± 2.9 (−8.9 to 7.7)	<0.0001
p value‡	0.13	0.0006	0.003	0.0015	0.025	
lordosis angle (°)						
ACDF (n = 72)	12.6 ± 8.3 (0.9–29.7)	14.2 ± 8.0 (0.7–29.6)	13.6 ± 8.6 (0.5–33.1)	1.6 ± 4.1 (−14.2 to 8.7)	1.0 ± 5.2 (−21.8 to 11.5)	0.27
ACCF (n = 36)	11.3 ± 9.5 (1.2–1.2)	10.3 ± 8.6 (1.2–30.4)	9.7 ± 7.7 (1.2–34.2)	−1.0 ± 4.0 (−12.2 to 4.6)	−1.5 ± 5.4 (−24.2 to 4.6)	0.41
p value§	0.45	0.02	0.02	0.003	0.02	

* Measurement values are presented as the mean ± SD. FU = follow-up.
† Last follow-up was performed at a mean of 20.4 ± 13.7 months (range 9.9–90.5 months) after surgery.
‡ p value for comparisons of differences for "postop to preop" and "last follow-up to preop."
§ p value for comparisons of ACDF and ACCF treatments.

ical outcomes, which might have explained the slightly better outcomes after ACCF. In our study, there was a similarly good outcome in each group and the 2 groups showed similarly high fusion rates.

With regards to surgical parameters, general (medical) and surgical complication rates were similar in both groups; only blood loss was significantly higher in the ACCF than in the ACDF treatment. This difference has been described in the literature before and is probably due to the more invasive surgical approach involved in removing a vertebral body.[5,12] The duration of surgery was comparable for the 2 groups as might be expected: in both techniques, two discs are removed, and the longer time required for removing the vertebral body in ACCF is compensated for by the fusion procedure, since in ACDF 2 segments need to be fused whereas in ACCF only 1. Some studies have reported a significantly longer time of surgery for ACCF although most of these studies involved multilevel ACDF and ACCF.[5,10]

The radiographic findings in our study were comparable to those reported in previously published studies.[11,15] Compared with ACCF, segmental height was significantly greater in the ACDF group, both immediately after surgery and at the last follow-up; lordosis angle increased slightly in the ACDF group and decreased slightly in the ACCF group, leading to significant group differences at each time point. We assume that the reason for this is the more effective distraction and change in lordosis angle over 2 levels in ACDF compared with ACCF. Oh et al. also described a postoperative increase in segmental height in both ACDF and ACCF groups with a significantly greater increase and a better improvement in lordosis angle in the ACDF group.[10] Segmental height showed a significant reduction in both groups over time, from immediately after surgery up to the last follow-up. Park et al. also described subsidence over time in 52 ACCF and 45 ACDF cases, with a peak occurring within the first 6 weeks after surgery and no significant difference between the 2 groups.[11] The subsidence might be explained by postoperative migration of the cage or iliac bone into the cover plate of the adjacent vertebral bodies leading to a subsidence of the treated segment. Our nonunion rate in 1-level ACCF (5.3%) was comparable to that reported for the same procedure in recent studies, but the nonunion rate in 2-level ACDF patients was much lower (2.5%) in our study than in others.[5] When the pooled data from the recently published meta-analysis are examined in more detail, it appears that the high nonunion rates after ACDF were based on relatively old studies.[1,17] The higher rates might have been the result of poorer techniques and materials because recent studies have shown fusion rates for the 2 groups[15] that are comparable to those presented in the current study.

The increase in lordosis angle showed a significant correlation with the improvement in some patient-rated outcomes including arm pain, highest pain (neck or arm), and function. However, the size of the effect was not large, with the radiographic changes accounting for just 6% of the variance in clinical outcomes. Gum et al. previously showed that the maintenance or restoration of lordosis improved patient outcomes after ACDF.[3] The

TABLE 5: Group differences in outcome at 12 months postsurgery

Variable	ACCF (n = 35)	ACDF (n = 74)	p Value
12-mo FU rate (%)	35/38 (92.1)	74/80 (92.5)	0.94
12-mo global outcome (%)			
good	68.6	82.4	
poor	31.4	17.6	0.10
12-mo satisfaction (%)			
good	82.9	86.5	
poor	17.1	13.5	0.62
change in COMI score from preop to 12 mos postop*			
neck pain on 0–10 scale	0.9 (3.1)	1.3 (3.2)	0.56
arm pain on 0–10 scale	1.4 (3.2)	2.4 (2.7)	0.14
worst pain (either neck or arm) on 0–10 scale	1.5 (3.2)	2.0 (2.7)	0.35
function on 1–5 scale	0.9 (1.5)	1.0 (1.2)	0.55
symptom-specific well-being on 1–5 scale	1.2 (1.6)	1.6 (1.7)	0.31
general quality of life on 1–5 scale	0.8 (1.0)	1.1 (1.0)	0.19
disability (average, social & work) on 1–5 scale	1.0 (2.0)	1.0 (1.7)	0.82
COMI sum score on 0–10 scale	2.2 (3.0)	2.8 (2.7)	0.30

* Score are presented as the mean (SD). The decreases in COMI domain scores and the preoperative COMI sum score to 12 months postoperatively were all significant at $p < 0.0001$, except for neck pain, which was $p = 0.001$.

achievement of solid fusion was not significantly associated with a good clinical outcome, although the patient numbers in the pseudarthrosis group were likely too low to allow valid analysis.

Our study has some limitations, including its retrospective nature (albeit of prospectively collected data) and the lack of randomization of the patients to either the ACDF or the ACCF treatment. Instead, the surgical procedure was chosen by the treating surgeon. Further, 2 different materials for fusion were used in ACDF (cage or iliac bone), with or without plate fixation, and a different cage type was used for ACDF and ACCF patients. Nonetheless, on the basis of patient-rated outcome measures, collected with a very high follow-up rate of 92.4%, this study showed that both ACDF and ACCF techniques resulted in a high proportion of patients reporting a good global outcome (operation helped/helped a lot) and satisfaction with care.

Conclusions

The similarity between the groups, ACDF and ACCF, precludes any firm conclusions regarding the superiority of one technique over the other, but it should be borne in mind that ACDF was associated with significantly less blood loss, greater cervical lordosis, and higher segmental height. In turn, on an individual basis, a low but nonetheless significant tendency to have a better clinical outcome was seen in patients having an improved lordosis angle.

Disclosure

Dr. Jeszenszky serves as a consultant for DePuy Synthes.

Author contributions to the study and manuscript preparation include the following. Conception and design: Burkhardt, Porchet. Acquisition of data: Burkhardt, Marbacher, Dolp. Analysis and interpretation of data: all authors. Drafting the article: Burkhardt, Mannion, Marbacher, Porchet. Critically revising the article: Burkhardt, Mannion, Marbacher, Fekete, Jeszenszky, Porchet. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Burkhardt. Statistical analysis: Mannion, Fekete. Administrative/technical/material support: Mannion, Porchet. Study supervision: Mannion, Jeszenszky, Porchet.

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Manuscript submitted March 11, 2013.
Accepted March 27, 2013.
Please include this information when citing this paper: DOI: 10.3171/2013.3.FOCUS1396.

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